PROPOSED U. S. QUANTITY-DISTANCE RULES FOR HAZARD DIVISION 1.2 AMMUNITION

by

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ABSTRACT

An extensive Hazard Division (HD) 1.2 open-air testing program has been completed and is being reported on separately at this seminar. The results of both this program and a literature survey form the basis of a data base of HD 1.2 effects. Currently, for quantity-distance purposes, HD 1.2 ammunition is treated differently than HD 1.1 items. The data base of HD 1.2 effects suggests that this difference is not appropriate. Based on this data base, proposed changes to the US quantity-distance criteria for HD 1.2 ammunition have been developed. This paper will describe those proposed changes. It will then compare the proposed change to the US criteria with both the current US and NATO/UK criteria.

INTRODUCTION

Interim or status reports on the US/UK Hazard Division (HD) 1.2 testing program were previously presented at both the United States and Australian Safety Seminars¹⁻⁴. Since then, additional testing has been completed both in the United States and in Germany. The US/UK testing program is described in a separate paper that is being presented at this seminar. The results of these testing programs have been used to revise the description of the accepted behavior of HD 1.2 items. These results also form the basis for proposed changes to the appropriate explosives safety standards. The subsequent sections of this paper will discuss these topics in more detail.

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1. REPORT DATE AUG 1996		2. REPORT TYPE	3. DATES COVERED 00-00-1996 to 00-00-1996			
4. TITLE AND SUBTITLE				5a. CONTRACT	NUMBER	
Proposed U.S. Qua Ammunition	ntity-Distance Rule	on 1.2	5b. GRANT NUM	1BER		
Ammumuon				5c. PROGRAM E	LEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NU	JMBER	
				5e. TASK NUMB	ER	
				5f. WORK UNIT	NUMBER	
	·	DDRESS(ES) Head Division,101 S	Strauss	8. PERFORMING REPORT NUMB	GORGANIZATION ER	
9. SPONSORING/MONITO	RING AGENCY NAME(S) A	ND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S)		
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)		
12. DISTRIBUTION/AVAIL Approved for publ	LABILITY STATEMENT ic release; distributi	on unlimited				
13. SUPPLEMENTARY NO See also ADM0007 Vegas, NV on 22-24	67. Proceedings of t	he Twenty-Seventh	DoD Explosives S	Safety Semina	ar Held in Las	
14. ABSTRACT see report						
15. SUBJECT TERMS						
16. SECURITY CLASSIFIC	17. LIMITATION OF	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON			
a. REPORT b. ABSTRACT c. THIS PAGE Same as unclassified unclassified unclassified Report (SAR)			20	RESPUNSIBLE PERSON		

Report Documentation Page

Form Approved OMB No. 0704-0188

THE US/UK TESTING PROGRAM

The testing portion of the US/UK-sponsored HD 1.2 open-air testing program has been concluded. During this effort, fourteen tests have been completed and analyzed. These are shown in Table 1.

TABLE 1. US/UK HD 1.2 TESTING PROGRAM IN OPEN AIR

TEST	NUMBER	BOXES	NUMBER	TEST	TEST	TYPE	TYPE
IDENTIFIER	OF	PER	OF	DATE	ITEM	OF	OF
	PALLETS	PALLET	ROUNDS			вох	TEST
1	1	15	30	7-May-91	105 mm/TNT	Wood	External Fire
2	1	15	30	24-Jun-91	105 mm/TNT	Wood	External Fire
3	1	15	30	29-Jul-91	105 mm/TNT	Wood	External Fire
4	8	15	240	29-Oct-91	105 mm/TNT	Wood	External Fire
5	8	15	240	29-Apr-92	105 mm/TNT	Wood	External Fire
6	27	16	864	28-Oct-92	105 mm/TNT	Wood	External Fire
7	3	16	96	3-May-94	105 mm/COMP B*	Wood	External Fire
8	2	30	180	15-Sep-94	81 mm/COMP B	Wood	External Fire
8A			12	8-Sep-94	81 mm/COMP B	Metal	External Fire**
9	2	30	180	11-May-95	81 mm/COMP B	Metal	External Fire
10	4	16	128	17-May-95	105 mm/COMP B	Wood	External Fire
11A			15	20-Sep-95	81 mm/Comp B	Metal	Stack**
11B			15	20-Sep-95	81 mm/Comp B	Metal	External Fire**
12	8	30	720	26-Sep-95	81 mm/COMP B	Metal	External Fire

^{*} tested without nose plugs

The US/UK program has used three separate rounds. These are: (1) 105 mm, TNT-loaded cartridge, (2) 105-mm, Composition B-loaded cartridge, and (3) 81 mm, Composition B-loaded cartridge.

The M1 105 mm cartridge is a semi-fixed high explosive artillery round. The projectile body is fabricated from forged steel and weighs approximately 25.8 pounds (11.7 kg). An aluminum shipping plug is assembled into the nose of the projectile in lieu of a fuze. The propelling charge consists of approximately 3 pounds (1.4 kg) of M1 propellant contained in a spiral wrap steel case. Each propelling charge case weighs approximately 4.7 pounds (2.1 kg). Several variants of the M1 cartridge have been produced with projectiles that contain either TNT or Composition B explosive. Each round contains approximately 4.5 pounds (2.0 kg) of high explosive. The item is packaged two to a wooden box. A pallet consists of either 15 or 16

^{**}pseudo-hazard classification tests

wooden boxes. The item is currently hazard classified in the United States as (12)1.2E; i.e., its maximum fragment range is 1200 feet (366 m) based on the original hazard classification testing.

The items tested were taken from ammunition with the following DODIC/NSN/NALC (Department of Defense Information Code/National Stock Number/Naval Ammunition Logistics Code):

TABLE 2. M1 105 mm ROUNDS TESTED

TNT	COMPOSITION B
C445 1315-00-145-7554	C445 1315-00-028-4857
C445 1315-00-146-6853	C445 1315-00-028-4860
C445 1315-00-215-8884	C445 1315-00-231-4629
	C445 1315-00-926-4081

The M374A2 is an unfuzed, 81 mm mortar cartridge. The complete round consists of a projectile body, a fin assembly that includes a cartridge housing, a propellant charge with two types of increment charges, and an ignition charge. Each round contains 2.1 pounds (0.95 kg) of Composition B explosive and 0.33 pounds (0.15 kg) of M1 propellant. The item is packaged one per container, three containers per wooden box. A pallet consists of 30 boxes. The round is currently hazard classified in the United States as (08)1.2E; i.e., its maximum fragment range is 800 feet (244 m) based on the original hazard classification testing. The items tested were taken from ammunition with the following DODIC/NSN/NALC:

C236 1315-00-935-6007 C236 1315-00-935-6013

The 81-mm mortar rounds used on Tests 8 and 10 were in their standard packaging. This consisted of each round packaged in a fiberboard tube, with three such tubes inside each wooden box. The wooden boxes were formed into pallets with 30 boxes on each pallet. To investigate the effects of the packaging on the observed HD 1.2 behavior, rounds were repackaged for several tests (Tests 8A, 9, 11A, 11B, and 12). Rounds were removed from their regular packaging. Each round was placed inside a plastic handling tube. These plastic tubes were then placed in metal boxes (three rounds to a box). On Tests 9 and 12, the metal boxes were stacked into pallet configurations. These pallets had the same approximate dimensions as those containing wooden boxes and contained the same numbers of rounds. The test configurations for Tests 8A, 11A, and 11B were similar to those used for hazard classification purposes. These tests were performed to insure that the change in packaging does not result in an apparent change in the hazard classification to HD 1.1.

OTHER DATA

Beyond the data collected by this program, related information has been obtained from the published literature and from other test reports describing recent work. This information includes Japanese work on 105 mm projectiles⁵, and Norwegian⁶, US⁷, and German⁸ work on 40 mm projectiles.

The Japanese paper describes bonfire tests conducted on TNT-loaded, 105 mm projectiles inside a tunnel--simulating underground storage. These results confirmed the type of behavior observed on the US/UK open-air tests. There was a delay of at least 15-20 minutes after the start of the fire before the first event occurred. After that first event, the rounds reacted sequentially "popcorn-fashion."

The Norwegian 40 mm data were obtained as part of an investigation of a shipping accident. The data obtained from this study were used to calculate fragment density versus range information for this round. These test data indicated that this round had a maximum fragment range of approximately 500 feet (152 m).

About fifteen years ago, as part of the Fragment Hazard Investigation Program, the Department of Defense Explosives Safety Board (DDESB) sponsored a series of large bonfire tests of 40 mm antiaircraft rounds. This series of tests culminated in an event involving over 6000 rounds of 40 mm ammunition. Because of the large number of rounds involved, the statistics of the recovery process meant that the maximum fragment range should be well defined; i.e., because of the large numbers of rounds involved, the probability of recovering a fragment near the true maximum range should be high. A recent, detailed examination of both how the test was conducted and the data obtained indicates that there may be problems with this data set. The exact nature of the rounds tested cannot be determined; i.e., neither the type of round (description and DODIC/NSN/NALC) nor weight of either the explosive or propellant was available. Further, the test site had been previously used for other testing and the fragment recovery operations were not under the direct supervision of project personnel. Thus, items from previous tests could have been attributed to the 40-mm test results. Because of these questions, the authors have chosen not to give this data set as much credibility as the other data described in this section.

Under the auspices of NATO AC/258, Germany is currently acquiring data on three of their 40 mm rounds. Thus far, two external fire tests have been conducted with full fragment recovery. Preliminary data from these tests have been made available and the results have been added to the data base.

Other tests are in various stages of preparation. France is currently planning a series of external fire tests using HD 1.2 rocket motors (R530 missiles without warheads). The UK and Australia are planning to conduct a bonfire test inside a SPANTECH igloo filled with 105 mm projectiles. This test is a follow-up to smaller scale one and eight pallet tests in the same igloo. The US is analyzing the results of bonfire tests conducted inside a miniature magazine. As these data become available, they will be included in the data base and compared with the remaining data.

CURRENT RULES

The current NATO and UK QD prescriptions are defined in Allied Ammunition Storage and Transport Publication (AASTP-1) for NATO and ESTC leaflet 5 Part 2 for the UK. Under this system, there is a broad division, based loosely on calibre, into:

- those items which give small fragments of moderate range (calibre < 60 mm):
 D=53Q^{0.18} (D in meters, Q is Net Explosive Quantity (NEQ) in kilograms) with a minimum of 180 meters and a maximum of 410 m.
- (ii) those items which give large fragments with considerable range (calibre > 60 mm): D= $62Q^{0.18}$ (D in meters, Q is Net Explosive Quantity (NEQ) in kilograms) with a minimum of 270 meters and a maximum of 560 m.

NOTE: The 60 mm division is considered somewhat arbitrary; however, it is purported to be based on test data that is either not currently available or cannot be found.

US quantity-distance regulations are defined in the Department of Defense Ammunition and Explosives Safety Standards⁹. Currently, for HD 1.2 items, safety distances are related to the maximum range of hazardous projections as determined by hazard classification tests that are performed for that specific ammunition item.

The NATO and UK criteria differ in principle from the current US criteria. The US criteria are round specific and quantity independent whereas the NATO/UK criteria are round generic and quantity dependent. There is one other major difference between the US and the NATO/UK approaches. That involves the calculation of the NEQ or NEW. In the US, the weight of any HD 1.3 material is considered part of the total NEW. Under the NATO/UK approach, only those explosives shown to contribute to the explosion effects need to be considered, although, in practice, the total NEQ of the article is taken as no reliable data exists to do otherwise.

PROPOSED APPROACH FOR QUANTITY-DISTANCE RULE CHANGES IN THE UNITED STATES

Based on the data that has been obtained and/or analyzed during this program, an approach similar to that taken by NATO and the UK seems appropriate. Namely, a quantity-distance (QD) range that is dependent upon a combination of: (1) the Net Explosive Weight (NEW) of a single round and (2) the total HD 1.1 weight of all the items in the stack. This would obviate the requirement for a fragment recovery test for every new weapon system. The NEW or NEQ for a single round is the weight of the HD 1.1 material plus the weight of any HD 1.3 material known to contribute to the event. Based on the data that have been obtained to date, for the purposes of quantity-distance determination, it is assumed that the HD 1.3 material does not contribute unless there is evidence otherwise. In some situations, there may only be HD 1.3 materials and no HD 1.1 materials present. Examples of these might include certain rocket motors or kinetic energy penetration rounds. In these situations, the HD 1.3 weight should be used as the basis for quantity-distance calculations.

The approach described herein represents the current thinking of the authors. It has evolved over the last two years and is significantly different from the material presented at the Australian Safety Seminar in October 1995². This material has not been fully staffed and does not represent an official position. Further, since related testing is still underway, these ideas should be taken as generic and evolving, rather than representing an absolute answer.

The following definitions are required for this section. The Net Explosive Weight (NEW) of an item is the sum of the weight of the HD 1.1 and 1.3 material contained in an item. The Net Explosive Weight for QD (NEW/QD) for an item includes a 100% contribution of the HD 1.1 material and any known or documented contribution of the HD 1.3 materials. The Quantity-Distance Weight (QDW) is equal to the number of items multiplied by the NEW/QD for a single item. The Maximum Credible Event (MCE) is the total weight of the HD 1.1 and 1.3 material that would be involved in the worst single event that is likely to occur.

The effects produced by the functioning of HD 1.2 items will vary with the size and weight of the item. HD 1.2 ammunition can be segregated into two categories to account for the differences in magnitude of these effects for purposes of setting quantity-distance criteria for storage. The least hazardous items, called Category 1 items, have an NEW/QD less than or equal to 0.30 lbs (0.135 kg). The more hazardous items are called Category 2 items and have an NEW/QD greater than or equal to 0.30 pounds. These two categories are shown below with their definitions:

CATEGORY 1: NEW/QD < 0.30 lbs CATEGORY 2: NEW/QD > 0.30 lbs

The breakpoint between the two categories is based on all of the test data that is currently available. Category 1 uses a combination of the Norwegian and German 40 mm data. Category 2 is based on a combination of the 81 mm mortar and 105 mm cartridge data. Within each Category, a curve fit of the type:

$$IBD = A + B*(ln(QDW)) + C*(ln(QDW))^2$$

was made to the maxima of the data. For Category 1, the Norwegian data was dominant for low values of QDW, while the German data controlled the fit at large values of QDW. For Category 2, the 81 mm data controlled the results except at large values of QDW. These equations are shown in the Notes at the bottoms of Tables 3 and 4.

Tables 3 and 4 show the proposed inhabited building distances (IBD), public traffic route distances (PTR), and intraline distances (ILD) for the two Categories of HD 1.2 ammunition. Intermagazine distances (IMD) are dependent upon the types of structures acting as both the Potential Explosion Site (PES) and the Exposed Site (ES). Table 5 provides the appropriate IMD separations for various combinations of ES and PES.

PTR distances which are also shown in Tables 3 and 4 give consideration to the transient nature of the exposure in the same manner as for HD 1.1. PTR distance is computed as 60% of the IBD for items in this hazard division.

TABLE 3. PROPOSED HD 1.2 QUANTITY-DISTANCES
(IBD, PTR, ILD) FOR CATEGORY 1

(NEW/QD < 0.30 lbs)

QDW	IBD ^{1,2}	PTR ³	ILD⁴		QDW	IBD ^{1,2}	PTR ³	ILD⁴
(lbs)	(ft)	(ft)	(ft)		(lbs)	(ft)	(ft)	(ft)
1	328	197	164	L	7,000	434	260	217
2	328	197	164	L	8,000	438	263	219
5	328	197	164	L	9,000	441	264	220
10	328	197	164	L	10,000	444	266	222
20	328	197	164	L	15,000	454	272	227
40	328	197	164	L	20,000	460	276	230
60	328	197	164	L	25,000	466	279	233
80	328	197	164	L	30,000	469	282	235
100	328	197	164	L	40,000	475	285	238
150	328	197	164	L	50,000	480	288	240
200	328	197	164	L	60,000	483	290	242
300	328	197	164	L	70,000	486	292	243
400	338	203	202⁵	L	80,000	488	293	244
600	354	212	228⁵	L	90,000	490	294	245
800	364	219	247 ⁵	L	100,000	492	295	246
1,000	373	224	261⁵	L	150,000	498	299	249
1,500	387	232	287⁵	L	200,000	502	301	251
2,000	396	238	304 ⁵	L	250,000	505	303	253
2,500	403	242	318⁵	L	300,000	507	304	254
3,000	409	246	329⁵	L	350,000	509	305	254
3,500	414	248	338⁵	L	400,000	510	306	255
4,000	418	251	346⁵	L	450,000	512	307	256
5,000	425	255	360⁵	L	500,000	513	308	256
6,000	430	258	215		>500,000	520	312	260

NOTES:

- (1) IBD = $24.7 + 65.0*(ln(QDW))-2.12*(ln(QDW))^2$ QDW in pounds, IBD in feet with a 328 feet minimum distance
- (2) Use of equation to determine IBD ranges for other weights is allowed
- (3) PTR = 60% of IBD
- (4) ILD = 50% of IBD
- (5) If the QDW of Category 1 HD 1.2 items at an operating line PES is limited to 5,000 pounds, then ILD may be reduced to 200 feet

TABLE 4. PROPOSED HD 1.2 QUANTITY-DISTANCES (IBD, PTR, ILD) FOR CATEGORY 2 (NEW/QD \geq 0.30 lbs)

QDW (lbs)	IBD ^{1,2} (ft)	PTR ³ (ft)	ILD⁴ (ft)		QDW (lbs)	IBD ^{1,2} (ft)	PTR ³ (ft)	ILD ⁴ (ft)
1	656	394	328		7,000	1317	790	659
2	656	394	328		8,000	1341	805	670
5	656	394	328		9,000	1362	817	681
10	656	394	328		10,000	1380	828	690
20	656	394	328		15,000	1449	870	725
40	656	394	328		20,000	1497	898	749
60	656	394	328	L	25,000	1534	920	767
80	656	394	328	L	30,000	1564	938	782
100	1250, 656 ⁵	750, 394 ⁵	625, 233 ⁵		40,000	1609	966	805
150	1250, 656 ⁵	750, 394 ⁵	625, 278 ⁵		50,000	1644	987	822
200	1250, 656 ⁵	750, 394 ⁵	625, 309 ⁵		60,000	1673	1004	836
300	1250, 706 ⁵	750, 423 ⁵	6253535		70,000	1696	1018	848
400	1250, 766 ⁵	750, 460⁵	625, 383 ⁵		80,000	1716	1030	858
600	1250, 849 ⁵	750, 510⁵	625, 425 ⁵		90,000	1734	1040	867
800	1250, 908 ⁵	750, 545⁵	625, 454 ⁵		100,000	1750	1050	875
1,000	1250, 952 ⁵	750, 571 ⁵	625, 476 ⁵		150,000	1809	1085	904
1,500	1250, 1032 ⁵	750, 619⁵	625, 516 ⁵		200,000	1849	1110	925
2,000	1250, 1087 ⁵	750, 652⁵	625, 544 ⁵		250,000	1881	1128	940
2,500	1250, 1129 ⁵	750, 678⁵	625, 565 ⁵		300,000	1905	1143	953
3,000	1250, 1164 ^t	750, 698⁵	625, 582 ⁵		350,000	1926	1156	963
3,500	1250, 1192 ⁵	750, 715⁵	625, 596⁵	L	400,000	1944	1166	972
4,000	1250, 1217 ⁵	750, 730 ⁵	625, 608 ⁵	L	450,000	1960	1176	980
5,000	1257	754	628	L	500,000	1974	1184	987
6,000	1290	774	645		>500,000	2000	1200	1000

NOTES:

- (1) IBD = $-678.3 + 273.9*(ln(QDW))-5.47*(ln(QDW))^2$ QDW in pounds, IBD in feet with a 656 feet minimum distance
- (2) Use of equation to determine IBD ranges for other weights is allowed
- (3) PTR = 60% of IBD
- (4) ILD = 50% of IBD
- (5) If the MCE for an item is known to be less than 100 pounds then the IBD equation given in Note (1) may be used and Notes (3) and (4) apply for PTR and ILD, respectively

TABLE 5. PROPOSED HAZARD DIVISION 1.2 INTERMAGAZINE DISTANCES

(note: all distances shown are in feet)

EXPOSED SITE (ES)	POTI	ENTIAL	EXPL	OSIÓN	SITE ((PES)
		ECM ¹		HWB ²	LWB ³	LWBB⁴
	FRONT	SIDE	REAR			
ECM (heavy)⁵Front	82 ^b	7 ^a	7 ^a	33 ^a	82 ^b	33 ^a
ECM (heavy)⁵Side	7 ^a					
ECM (heavy)⁵Rear	7 ^a					
ECM (light)6Front	164 ^{a'}					
ECM (light)6Side	7 ^a					
ECM (light)6Rear	7 ^a					
ECM1barricadedFront	82 ^b	7 ^a	7 ^a	33 ^a	82 ^b	33 ^a
HWBR ⁷	33 ^a	7 ^a	7 ^a	33 ^a	33 ^a	33 ^a
HWB ²	164 ^{a'}					
LWB ³	164 ^{a'}					
LWBB⁴Front	164 ^a	164 ^{a'}	164 ^{a'}	164 ^a	164 ^{a'}	164 ^{a′}

NOTE 1: ECM is earth covered magazine

NOTE 2: HWB is building with walls > 17.7 inches reinforced concrete (27.6 inches brick). HWB door is barricaded if it faces PES.

NOTE 3: LWB is light structure, open stack, truck, trailer, or railcar --unbarricaded

NOTE 4: LWBB is same structure as LWB with barricade

NOTE 5: ECM (heavy) is an earth covered magazine with a head wall thickness > 5.9 inches

NOTE 6: ECM (light) is an earth covered magazine with a head wall thickness < 5.9 inches

NOTE 7: HWBR is building with walls ≥ 17.7 inches reinforced concrete (27.6 inches brick) and roof >5.9 inches concrete. HWBR door is barricaded if it faces PES.

NOTE 8: Superscripts on distances represent the levels of protection shown below:

a-level: There is virtually complete protection against immediate or subsequent fires and explosions caused by blast, flame, firebrands, projections and lobbed ammunition. The stocks are likely to be serviceable.

b-level: There is a high degree of protection against immediate propagation of explosion by blast, flame, and projections. There are occasional fires or subsequent explosions caused by firebrands, projections and lobbed ammunition. The extent of the loss of stocks at ES is determined by the effectiveness of the firefighting. If you increase b-level protection of 82 feet to 295 feet, a-level protection is obtained. If you increase b-level protection of 33 feet to 82 feet, a-level protection is obtained.

a'-level: 295 feet required for a-level protection.

ILD given in Tables 3 and 4 takes into account the progressive nature of explosions involving endangered areas before the progression involves large numbers of items. Exposed structures may be extensively damaged by projections and delayed propagation of explosions may occur due to the ignition of combustibles by projections. ILD is computed as 50% of the IBD for items of this hazard division.

When storing mixed Categories of HD 1.2 ammunition, the following rule shall apply. Use the total QDW and apply the distances for the higher Category. This is shown in Table 6.

CATEGORIES INVOLVED

DISTANCES TO BE APPLIED

Apply Category 1 Distances

Apply Category 2 Distances

1+2

Apply Category 2 Distances

TABLE 6. HAZARD DIVISION 1.2 MIXING RULES

Figure 1 compares the proposed changes to the US criteria with the current NATO/UK criteria. The IBD for US Category 1 munitions is less than the NATO/UK category for items with calibre <60 mm for all explosive weights. For larger items, this is not the case. For many items in US Category 2, the proposed US changes will require greater Inhabited Building Distances than the NATO/UK criteria.

ESTIMATED IMPACT OF PROPOSED CHANGES

A search of the United States Joint Hazard Classification System (JHCS) data base ¹⁰ has revealed that as of June 1996 there were 2,110 items that were hazard classified as HD 1.2. Table 7 shows how these HD 1.2 items were distributed. This table includes the kinds and numbers of items that could be affected by these proposed changes. Another way to estimate the impact of the changes is to look at their effect on selected ammunition items. These are shown in Tables 8 through 14. Each table gives a description of the item, the current US and NATO quantity-distance requirements and the new, proposed US requirement.

As expected, the new criteria present mixed results. That is, in some instances the new criteria would allow the storage of significantly more items with the same current hazard range. In other cases, significantly fewer items could be stored. This indicates that a transition period or rule should be developed to ease the change from the old rules to the new. Such a transition rule will be included with the final version of these changes.

FIGURE 1. COMPARISON OF PROPOSED US AND NATO/UK CRITERIA

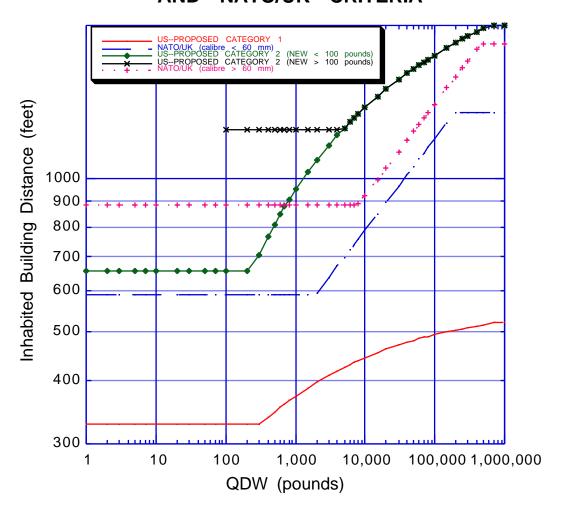


TABLE 7. HD 1.2 IBD DISTRIBUTION

CURRENT U.S. INHABITED BUILDING	WEIGHT	TOTAL	
DISTANCE	<0.30	<u>≥</u> 0.30	
(feet)			
200	4	2	6
300	1	0	1
400	508	181	689
500	6	0	6
600	1	1	2
700	0	2	2
800	121	458	579
900	0	2	2
1000	0	2	2
1100	0	0	0
1200	87	701	788
1300	0	3	3
1400	0	0	0
1500	0	0	0
1600	0	0	0
1700	0	0	0
1800	0	30	30
TOTAL	728	1382	2110

TABLE 8. 25 mm CARTRIDGE

NUMBER OF	QDW	CURRENT	CURRENT	PROPOSED
ITEMS		US IBD	NATO IBD	US IBD
	(lbs)	(ft)	(ft)	(ft)
1	0.2324	400	591	328
5	1.162	400	591	328
10	2.324	400	591	328
20	4.648	400	591	328
50	11.62	400	591	328
100	23.24	400	591	328
200	46.48	400	591	328
500	116.2	400	591	328
1,000	232.4	400	591	328
1,500	348.6	400	591	333
2,000	464.8	400	591	344
5,000	1,162	400	591	378
10,000	2,324	400	609	401
20,000	4,648	400	690	422
50,000	11,620	400	813	447
100,000	23,240	400	921	464
200,000	46,480	400	1,044	478

DESCRIPTION	CTG, 25 mm, APFSDS-T, M919, M261 CNTR		
DODIC	A986		
NEW/QD (lbs)	0.2324		
US/IBD (ft)	400		
HD 1.1 weight (lbs)	0		
HD 1.3 weight (lbs)	0.2324		

TABLE 9. 40 mm Cartridge

NUMBER OF	QDW	CURRENT	CURRENT	PROPOSED
ITEMS		US IBD	NATO IBD	US IBD
	(lbs)	(ft)	(ft)	(ft)
1	0.202	800	591	328
5	1.01	800	591	328
10	2.02	800	591	328
20	4.04	800	591	328
50	10.1	800	591	328
100	20.2	800	591	328
200	40.4	800	591	328
500	101	800	591	328
1,000	202	800	591	328
2,000	404	800	591	338
5,000	1,010	800	591	373
10,000	2,020	800	594	397
20,000	4,040	800	672	418
50,000	10,100	800	793	444
100,000	20,200	800	898	461
200,000	40,400	800	1,018	476
500,000	101,000	800	1,200	492

DESCRIPTION	CTG, 40 mm, HEI-P-NP
DODIC	B556
NEW/QD (lbs)	0.2020
US/IBD (ft)	800
HD 1.1 weight (lbs)	0.2020
HD 1.3 weight (lbs)	0.007

TABLE 10. Mine, AP, M16A2

NUMBER OF	QDW	CURRENT	CURRENT	PROPOSED
ITEMS		US IBD	NATO IBD	US IBD
	(lbs)	(ft)	(ft)	(ft)
1	1.33552	800	886	656
5	6.6776	800	886	656
10	13.3552	800	886	656
20	26.7104	800	886	656
50	66.776	800	886	656
100	133.552	800	886	656
200	267.104	800	886	681
500	667.76	800	886	872
1,000	1335.52	800	886	1009
1,500	2003.28	800	886	1088
2,000	2671.04	800	886	1142
3,000	4006.56	800	886	1217
5,000	6,678	800	944	1309
10,000	13,355	800	1,070	1430
20,000	26,710	800	1,212	1545
50,000	66,776	800	1,429	1689
100,000	133,552	800	1,619	1792
200,000	267,104	800	1,834	1890

DESCRIPTION	Mine, AP M16A2 W/M605 Fuze	
DODIC	K092	
NEW/QD (lbs)	1.33552	
US/IBD (ft)	800	
HD 1.1 weight (lbs)	1.33552	
HD 1.3 weight (lbs)	0	

TABLE 11. 81 mm Mortar

NUMBER OF ITEMS	QDW	CURRENT US IBD	CURRENT NATO IBD	PROPOSED US IBD
	(lbs)	(ft)	(ft)	(ft)
1	2.426	800	886	656
5	12.13	800	886	656
10	24.26	800	886	656
20	48.52	800	886	656
50	121.3	800	886	656
100	242.6	800	886	660
200	485.2	800	886	806
500	1213	800	886	990
1,000	2426	800	886	1124
1,500	3639	800	886	1199
2,000	4852	800	892	1252
5,000	12,130	800	1052	1413
10,000	24,260	800	1191	1529
20,000	48,520	800	1350	1640
50,000	121,300	800	1,592	1778
100,000	242,600	800	1,803	1876
200,000	485,200	800	1,837	1970
250,000	606,500	800	1,837	2000

DESCRIPTION	CTG, 81 mm, HE, M374 W/O Fuze	
DODIC	C236	
NEW/QD (lbs)	2.426	
US/IBD (ft)	800	
HD 1.1 weight (lbs)	2.193	
HD 1.3 weight (lbs)	0.233	

TABLE 12. Cartridge, M1, 105 mm

NUMBER OF	QDW	CURRENT	CURRENT	PROPOSED
ITEMS		US IBD	NATO IBD	US IBD
	(lbs)	(ft)	(ft)	(ft)
1	5.08	1,200	886	656
5	25.4	1,200	886	656
10	50.8	1,200	886	656
20	101.6	1,200	886	656
50	254	1,200	886	670
100	508	1,200	886	815
200	1,016	1,200	886	955
500	2,540	1,200	886	1,132
1,000	5,080	1,200	899	1,260
1,500	7,620	1,200	967	1,332
2,000	10,160	1,200	1,018	1,383
5,000	25,400	1,200	1,201	1,537
10,000	50,800	1,200	1,361	1,647
20,000	101,600	1,200	1,542	1,752
50,000	254,000	1,200	1,818	1,883
70,000	355,600	1,200	1,837	1,928

DESCRIPTION	CTG, 105 mm, M1	
DODIC	C445	
NEW/QD (lbs)	5.08	
US/IBD (ft)	1200	
HD 1.1 weight (lbs)	5.08	
HD 1.3 weight (lbs)	2.88	

TABLE 13. AGM-88A (HARM)

NUMBER OF	QDW	CURRENT	CURRENT	PROPOSED
ITEMS		US IBD	NATO IBD	US IBD
	(lbs)	(ft)	(ft)	(ft)
1	46.4	400	886	656
2	92.8	400	886	656
5	232.1	400	886	656
7	325	400	886	722
10	464	400	886	797
15	696	400	886	880
20	928	400	886	937
50	2,321	400	886	1,115
70	3,249	400	886	1,178
100	4,641	400	886	1,244
150	6,962	400	951	1,316
200	9,283	400	1,002	1,367
500	23,207	400	1,182	1,522
700	32,490	400	1,256	1,576
1,000	46,414	400	1,339	1,633
1,500	69,622	400	1,440	1,695

DESCRIPTION	G/M, AGM-88A
DODIC	PB24
NEW/QD (lbs)	46.4144
US/IBD (ft)	400
HD 1.1 weight (lbs)	46.4144
HD 1.3 weight (lbs)	327.414

TABLE 14. Dispenser and Bomb, CBU-71A/B

NUMBER OF	QDW	CURRENT	CURRENT	PROPOSED
ITEMS		US IBD	NATO IBD	US IBD
	(lbs)	(ft)	(ft)	(ft)
1	148	400	886	1,250
2	296	400	886	1,250
5	740	400	886	1,250
7	1,036	400	886	1,250
10	1,480	400	886	1,250
20	2,960	400	886	1,250
50	7,400	400	962	1,327
70	10,360	400	1,022	1,386
100	14,800	400	1,090	1,447
200	29,600	400	1,235	1,561
500	74,000	400	1,456	1,705
700	103,600	400	1,547	1,755
1,000	148,000	400	1,650	1,807
1,500	222,000	400	1,774	1,864
2,000	296,000	400	1,837	1,904
3,000	444,000	400	1,837	1,958

DESCRIPTION	Dispenser and Bomb, CBU-71 A/B	
DODIC	E828	
NEW/QD (lbs)	148.0	
US/IBD (ft)	400	
HD 1.1 weight (lbs)	148.0	
HD 1.3 weight (lbs)	0	

SUMMARY

Sufficient data have been developed in the open air portion of the HD 1.2 program to indicate the probable course for suggested rule changes. These changes will take a form quite similar to that currently used by NATO and the UK--namely, that the IBD depends on the explosive weight raised to some power or powers with both a minimum and maximum range. Further the definition of the energetic material weight to be used in these calculations is nearly identical with that used in NATO/UK.

REFERENCES

- 1. Gould, M. J. A. And Houchins, W., D., "Trials To Determine The Consequences Of The Accidental Ignition Of Stacks Of Hazard Division 1.2 Ammunition," <u>Minutes of the 25th DoD Explosives Safety Seminar</u>, August 1992.
- 2. Gould, M. J. A., Houchins, W. D., Swisdak, M. M., and Rye, K. W., "Trials To Determine The Effects Of The Accidental Ignition Of Stacks Of Hazard Division 1.2 Ammunition," PARARI 93--Australian Safety Seminar, 26-28 October, 1993.
- 3. Gould, M. J. A. And Houchins, W., D., "Trials To Determine The Consequences Of The Accidental Ignition Of Stacks Of Hazard Division 1.2 Ammunition," <u>Minutes of the 26th DoD Explosives Safety Seminar</u>, August 1994.
- 4. Swisdak, M. M., Houchins, W. D., Ward, J. M., Gould, M. J. A., "Hazard Division 1.2 Effects From Open Stacks," PARARI 95--Australian Safety Seminar, 24-27 October, 1995.
- 5. Nakahara, Shoji, Motoba, Akio, and Katoh, Shin'ichi, "Explosion Tests In Model Underground Magazines: Part III--Bonfire Cookoff Test of Ammunition," October 1985.
- 6. "External Fire Test Carried Out on Norwegian 40 mm L/60 Ammunition for AA Gun," private communication LTCOL Steinbakken, 5 November 1986.
- 7. Smith, W. D., "Fragment Hazard Investigation Program: Non-Mass Detonating Ammunition Tests," <u>Minutes of the Twentieth DoD Explosives Safety Seminar</u>, August 1982.
- 8. "HD 1.2 40 mm Trials--Results of the Pilot Test," private communication LTCOL Muhr, 19 January 1996.
- 9. 6055.9-STD, DOD Ammunition and Explosives Safety Standards, October 1992.
- 10. NAVSEA Instruction 8020.8A, DOD Explosive Hazard Classification Procedures, December 1989.